PATENT COOPERATION TREATY

10/009128
5000

PCT

From the INTERNATIONAL BUREAU

To:

PELLMANN, Hans-Bernd
Tiedtke-Bühling-Kinne et al.
Bavariaring 4
D-80336 München
ALLEMAGNE

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

Date of mailing (day/month/year)	
24 January 2002 (24.01.02)	
Applicant's or agent's file reference WO24219	**IMPORTANT NOTIFICATION**
International application No. PCT/EP99/04237	**International filing date** (day/month/year) 18 June 1999 (18.06.99)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
NOKIA NETWORKS OY Keilalahdentie 4 FIN-02150 Espoo Finland	FI	FI
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
NOKIA CORPORATION Keilalahdentie 4 FIN-02150 Espoo Finland		
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Jaime LEITAO
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

To:

PELLMANN, Hans-Bernd
Tiedtke-Bühling-Kinne et al
Bavariaring 4
D-80336 München
ALLEMAGNE

10. DEZ. 1999

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

Date of mailing (day/month/year)
06 December 1999 (06.12.99)

Applicant's or agent's file reference
WO24219

IMPORTANT NOTIFICATION

International application No.
PCT/EP99/04237

International filing date (day/month/year)
18 June 1999 (18.06.99)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address
NOKIA TELECOMMUNICATIONS OY
Keilalahdentie 4
FIN-02150 Espoo
Finland

State of Nationality: FI
State of Residence: FI
Telephone No.: +358 9 1807 0
Facsimile No.: +358 9 1807 496
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address
NOKIA NETWORKS OY
Keilalahdentie 4
FIN-02150 Espoo
Finland

State of Nationality: FI
State of Residence: FI
Telephone No.: +358 9 1807 0
Facsimile No.: +358 9 1807 496
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[X] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
S. De Michiel
Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

PELLMANN, Hans-Bernd
Tiedtke-Bühling-Kinne et al.
Bavariaring 4
D-80336 München
ALLEMAGNE

EINGEGANGEN
Patentanwälte
30. AUG. 1999
TIEDTKE · BÜHLING · KINNE
& PARTNER

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
13 August 1999 (13.08.99)	
Applicant's or agent's file reference	**International application No.**
WO24219	PCT/EP99/04237

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

NOKIA TELECOMMUNICATIONS OY (for all designated States except US)
CORREIA, Americo, M., C. et al (for US)

International filing date	:	18 June 1999 (18.06.99)
Priority date(s) claimed	:	
Date of receipt of the record copy by the International Bureau	:	26 July 1999 (26.07.99)
List of designated Offices	:	

AP :GH,GM,KE,LS,MW,SD,SL,SZ,UG,ZW
EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
National :AE,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CU,CZ,DE,DK,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,US,UZ,VN,YU,ZA,ZW

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [ ] confirmation of precautionary designations
- [ ] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:
S. De Michiel

Telephone No. (41-22) 338.83.38

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents, the following is recalled.

Where the priority of an earlier national, regional or international application is claimed, the applicant must submit a copy of the said earlier application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date, provided that any such priority document may still be submitted to the International Bureau before that date of international publication of the international application, in which case that document will be considered to have been received by the International Bureau on the last day of the 16-month time limit (Rule 17.1(a)).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit and may be subjected by the receiving Office to the payment of a fee (Rule 17.1(b)).

If the priority document concerned is not submitted to the International Bureau or if the request to the receiving Office to prepare and transmit the priority document has not been made (and the corresponding fee, if any, paid) within the applicable time limit indicated under the preceding paragraphs, any designated State may disregard the priority claim, provided that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity to furnish the priority document within a time limit which is reasonable under the circumstances.

Where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
PELLMANN, Hans-Bernd
Tiedtke-Bühling-Kinne et al.
Bavariaring 4
D-80336 München
ALLEMAGNE

EINGEGANGEN
Patentanwälte
-5. Jan. 2001
TIEDTKE · BÜHLING · KINNE & PARTNER (GbR)

Date of mailing (day/month/year) 28 December 2000 (28.12.00)	
Applicant's or agent's file reference WO24219	**IMPORTANT NOTICE**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/EP99/04237	18 June 1999 (18.06.99)	

Applicant
NOKIA NETWORKS OY et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CU,CZ,DE,DK,EA,EE,EP,ES,FI,GB,GD,GE,GH, GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA, PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   28 December 2000 (28.12.00) under No. WO 00/79701

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

LESON, Thomas, Johannes, Alois
Tiedtke-Bühling-Kinne & Partner GbR
TBK-Patent
Bavariaring 4
80336 München
ALLEMAGNE

EINGEGANGEN
Patentanwälte
- 5. April 2001
TIEDTKE · BÜHLING · KINNE & PARTNER (GbR)

Date of mailing (day/month/year) 26 March 2001 (26.03.01)	
Applicant's or agent's file reference WO24219	**IMPORTANT INFORMATION**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/EP99/04237	18 June 1999 (18.06.99)	

Applicant
NOKIA NETWORKS OY et al

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   AP :GH,GM,KE,LS,MW,SD,SL,SZ,UG,ZW
   EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
   National :AU,BG,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
   OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
   National :AE,AL,AM,AT,AZ,BA,BB,BR,BY,CH,CU,DK,EE,ES,FI,GB,GD,GE,GH,GM,HR,
   HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MW,MX,PT,SD,SG,SI,SL,
   TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

   The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:
Claudio Borton

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

RECEIVED
EINGEGANGEN
01. Okt. 2001
TÜK PATENT

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

LESON, Thomas J. A.
TIEDTKE, BÜHLING, KINNE & PARTNER
Bavariaring 4
D-80336 München
ALLEMAGNE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	28.09.2001
Applicant's or agent's file reference WO24219	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/04237	18/06/1999	18/06/1999

Applicant
NOKIA NETWORKS OY et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Poquet Oliver, R Tel.+49 89 2399-2911

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

RECEIVED
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01 Okt. 2001
TBK - PATENT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
WO24219		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/04237	18/06/1999	18/06/1999
International Patent Classification (IPC) or national classification and IPC H04B7/06		
Applicant NOKIA NETWORKS OY et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
08/01/2001	28.09.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Koch, B Telephone No. +49 89 2399 7303

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/04237

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-20	as originally filed				

Claims, No.:

1-30	as received on	24/07/2001	with letter of	23/07/2001	

Drawings, sheets:

1/2,2/2	as originally filed				

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-30
	No:	Claims
Inventive step (IS)	Yes:	Claims 1-30
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1-30
	No:	Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. **Field:** The invention relates to a method (claim 1) and to apparati (claims 18 and 23) for transmission in a wireless diversity communication system.

2. **Prior Art:** D1 (US-A-5832044) discloses a diversity transmission method for transmitting a transmission signal in a wireless communication system, comprising the steps of:
   - dividing said transmission signal into a plurality of subsignals (cf. "components" in line 40, col. 3);
   - applying an orthonormal transformation (cf. lines 63-65 in col. 3) to said plurality of subsignals;
   - transmitting a first set of subsignals using a first diversity transmission scheme (cf. col. 3, lines 40-42);

   In this disclosure, different diversity schemes are merely disclosed as relevant for different embodiments, see col. 3, lines 40-44, but these different diversity schemes are not used within the same apparatus or method.

3. **Problem:** How to provide an alternative method/apparatus to mitigate the effects of multipath propagation in a wireless diversity communication system.

4. **Solution:** The invention solves this problem by
   - transmitting a second set of said subsignals using a second diversity transmission scheme, said second diversity transmission scheme being different form said first diversity transmission scheme.

   Neither D1 nor any other prior art available from the search report discloses or suggests the claimed way of splitting transmission signals into subsets and using different diversity transmission schemes for these two subsets.
   Claim 1 is therefore novel and inventive (Articles 33(2) and 33(3) PCT).

Apparatus claims 18 and 23 are directed to different ends of the communication system and comprise features corresponding to claim 1. They are novel and inventive for the same reasons as outlined above.

5. **Article 34(2)(b) PCT:**
The claims have been amended based on the originally filed claims and page 11, lines 14-16 (claims 6 and 21) of the description.

Re Item VII
Certain defects in the international application

1. Independent claims 18 and 23 are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art (document D1) being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).

Re Item VIII
Certain observations on the international application

1. Since they do not comprise the claimed feature d) of claim 1, nor any equivalent features reflecting the "second, different diversity transmission scheme fo a second subset", the embodiments of the invention described on page 8 line 12 to page 14 line 14 do not fall within the scope of the claims. This inconsistency between the claims and the description leads to doubt concerning the matter for which protection is sought, thereby rendering the claims unclear (Article 6 PCT).

Claims

1. A diversity transmission method for transmitting a transmission signal in a wireless communication system, comprising the steps of:

a) dividing said transmission signal into a plurality of subsignals;

b) applying an orthonormal transformation to said plurality of subsignals;

c) transmitting a first set of subsignals using a first diversity transmission scheme; and

d) transmitting a second set of said subsignals using a second diversity transmission scheme, said second diversity transmission scheme being different from said first diversity transmission scheme.

2. A method according to claim 1, wherein said first diversity transmission scheme is a space diversity transmission scheme.

3. A method according to claim 2, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

4. A method according to any one of the proceeding claims, wherein said second diversity transmission scheme is a frequency or time diversity scheme.

5. A method according to claim 4, wherein said second diversity transmission scheme is a complex diversity transform scheme.

6. A method according to claim 5, wherein said complex diversity transform scheme comprises an orthonormal transformation to a constellation which preserves Euclidean distances.

7. A method according to claim 5 or 6, wherein an original signal constellation represented as a matrix is used, and wherein each row of said matrix corresponds to a point in a multidimensional constellation.

8. A method according to claim 6 or 7, wherein said orthonormal transformation is achieved by a multiplication with a complex matrix.

9. A method according to claim 8, wherein each row of said complex matrix is orthogonal to any other row, and wherein the determinant of said matrix is equal to one.

10. A method according to claim 8 or 9, wherein said complex matrix is obtained based on an upperbound on the symbol error rate or based on a cutoff rate.

11. A method according to any one of claims 1 to 10, wherein said diversity transmission method is used in a downlink transmission of a cellular network.

12. A method according to any one of the preceding claims, wherein said transmission signal is a bit stream and said plurality of subsignals are substreams.

13. A method according to claim 12, wherein said transmission signal is a QPSK signal which can be represented by a vertex in a 2M-dimensional hyper-cube, where M denotes the dimension of a signal constellation.

14. A method according to any one of the preceding claims, wherein said wireless communication system is a WCDMA system.

15. A method according to any one of the preceding claims, wherein said first and second diversity transmission schemes comprise an open loop and/or a closed loop system.

16. A method according to any one of the preceding claims, wherein time slots of frequency carriers used in said second diversity transmission scheme are spaced apart to such a degree that independent fading is assured.

17. A method according to any one of the preceding claims, wherein said transmission signal comprises a signal constellation generated by optimizing the bit error rate and the peak to average ratio for a Rayleigh fading channel.

18. A transmitter for a diversity transmission system for transmitting a transmission signal in a wireless communication system, comprising:

a) dividing means **(10)** adapted to divide said transmission signal into a plurality of subsignals;

b) transforming means **(11)** adapted to apply an orthonormal transformation to said plurality of subsignals; and

c) transmitting means **(12)** adapted to transmit a first set of said subsignals using a first diversity transmission scheme, and a second set of said subsignals using a second diversity transmission scheme different from said first diversity transmission scheme.

19. A transmitter according to claim 18, wherein said first diversity transmission scheme is a space diversity transmission scheme using a plurality of transmission antennas **(A1-AM)**.

20. A transmitter according to claim 18 or 19, wherein said second diversity transmission scheme is a time or frequency diversity transmission scheme using a plurality of time slots or carrier frequencies.

21. A transmitter according to any one of claims 18 to 20, wherein said transforming means comprises a complex diversity transformation unit **(11)** arranged for performing an orthonormal transformation to a constellation which preserves Euclidean distances.

22. A transmitter according to any one of claims 18 to 21, wherein said transmitter is arranged in a WCDMA base station.

23. A receiver for a diversity transmission system, for receiving a transmission signal in a wireless communication system, comprising:

a) receiving means **(40, 4110, 4111, 4120, 4121, 41M0, 41M1, 421, 422,...42M)** adapted to receive a transmission signal comprising a first set of subsignals transmitted by using a first diversity transmission scheme, and a second set of subsignals transmitted by using a second diversity transmission scheme different from said first diversity transmission scheme; and

b) decoding means **(43)** adapted to decode said transmission signal by deciding on a maximum likelihood between said

received subsignals and corresponding estimated subsignals.

24. A receiver according to claim 23, further comprising channel estimation means **(44)** adapted to perform a channel estimation used for obtaining said corresponding estimated subsignals.

25. A receiver according to claim 23 or 24, wherein said first diversity transmission scheme is a space diversity transmission scheme.

26. A receiver according to claim 25, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

27. A receiver according to any one of claims 23 to 26, wherein said second diversity scheme is a time or frequency diversity scheme.

28. A receiver according to claim 27, wherein said time or frequency diversity scheme is a complex diversity transformation scheme.

29. A receiver according to any one of claims 23 to 28, wherein said transmission signal is a QPSK signal and said receiving means comprises a bank of 2M correlators, wherein M denotes the number of transmission antennas used in said first diversity transmission scheme.

30. A receiver according to any one of claims 23 to 29, wherein said receiver is arranged in a mobile WCDMA terminal of a cellular network.

REPLACED BY ART 34 AMDT

Claims

1. A diversity transmission method for transmitting a transmission signal in a wireless communication system, comprising the steps of:

a) dividing said transmission signal into a plurality of subsignals;

b) applying an orthonormal transformation to said plurality of subsignals;

c) transmitting a first set of subsignals using a first diversity transmission scheme; and

d) transmitting a second set of said subsignals using a second diversity transmission scheme, said second diversity transmission scheme being different form said first diversity transmission scheme.

2. A method according to claim 1, wherein said first diversity transmission scheme is a space diversity transmission scheme.

3. A method according to claim 2, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

4. A method according to any one of the proceeding claims, wherein said second diversity transmission scheme is a frequency or time diversity scheme.

5. A method according to claim 4, wherein said second diversity transmission scheme is a complex diversity transform scheme.

6. A method according to claim 5, wherein said complex diversity transform scheme comprises an orthonormal

transformation to a constellation which preserves Euclidean distances but improves the resistances to fading.

7. A method according to claim 5 or 6, wherein an original signal constellation represented as a matrix is used, and wherein each row of said matrix corresponds to a point in a multidimensional constellation.

8. A method according to claim 6 or 7, wherein said orthonormal transformation is achieved by a multiplication with a complex matrix.

9. A method according to claim 8, wherein each row of said complex matrix is orthogonal to any other row, and wherein the determinant of said matrix is equal to one.

10. A method according to claim 8 or 9, wherein said complex matrix is obtained based on an upperbound on the symbol error rate or based on a cutoff rate.

11. A method according to any one of claims 1 to 10, wherein said diversity transmission method is used in a downlink transmission of a cellular network.

12. A method according to any one of the preceding claims, wherein said transmission signal is a bit stream and said plurality of subsignals are substreams.

13. A method according to claim 12, wherein said transmission signal is a QPSK signal which can be represented by a vertex in a 2M-dimensional hyper-cube, where M denotes the dimension of a signal constellation.

14. A method according to any one of the preceding claims, wherein said wireless communication system is a WCDMA system.

15. A method according to any one of the preceding claims, wherein said first and second diversity transmission schemes comprise an open loop and/or a closed loop system.

16. A method according to any one of the preceding claims, wherein time slots of frequency carriers used in said second diversity transmission scheme are spaced apart to such a degree that independent fading is assured.

17. A method according to any one of the preceding claims, wherein said transmission signal comprises a signal constellation generated by optimizing the bit error rate and the peak to average ratio for a Rayleigh fading channel.

18. A transmitter for a diversity transmission system for transmitting a transmission signal in a wireless communication system, comprising:

a) dividing means **(10)** for dividing said transmission signal into a plurality of subsignals;

b) transforming means **(11)** for applying an orthonormal transformation to said plurality of subsignals; and

c) transmitting means **(12)** for transmitting a first set of said subsignals using a first diversity transmission scheme, and a second set of said subsignals using a second diversity transmission scheme different from said first diversity transmission scheme.

19. A transmitter according to claim 18, wherein said first diversity transmission scheme is a space diversity transmission scheme using a plurality of transmission antennas **(A1-AM)**.

20. A transmitter according to claim 18 or 19, wherein said second diversity transmission scheme is a time or frequency diversity transmission scheme using a plurality of time slots or carrier frequencies.

21. A transmitter according to any one of claims 18 to 20, wherein said transforming means comprises a complex diversity transformation unit **(11)** arranged for performing an orthonormal transformation to a constellation which preserves Euclidean distances but improves resistance to fading of an original signal constellation obtained from said dividing means **(10)**.

22. A transmitter according to any one of claims 18 to 21, wherein said transmitter is arranged in a WCDMA base station.

23. A receiver for a diversity transmission system, for receiving a transmission signal in a wireless communication system, comprising:

a) receiving means **(40, 4110, 4111, 4120, 4121, 41M0, 41M1, 421, 422,...42M)** for receiving a transmission signal comprising a first set of subsignals transmitted by using a first diversity transmission scheme, and a second set of subsignals transmitted by using a second diversity transmission scheme different from said first diversity transmission scheme; and

b) decoding means **(43)** for decoding said transmission signal by deciding on a maximum likelihood between said received subsignals and corresponding estimated subsignals.

24. A receiver according to claim 23, further comprising channel estimation means **(44)** for performing a channel estimation used for obtaining said corresponding estimated subsignals.

25. A receiver according to claim 23 or 24, wherein said first diversity transmission scheme is a space diversity transmission scheme.

26. A receiver according to claim 25, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

27. A receiver according to any one of claims 23 to 26, wherein said second diversity scheme is a time or frequency diversity scheme.

28. A receiver according to claim 27, wherein said time or frequency diversity scheme is a complex diversity transformation scheme.

29. A receiver according to any one of claims 23 to 28, wherein said transmission signal is a QPSK signal and said receiving means comprises a bank of 2M correlators, wherein M denotes the number of transmission antennas used in said first diversity transmission scheme.

30. A receiver according to any one of claims 23 to 29, wherein said receiver is arranged in a mobile WCDMA terminal of a cellular network.

PCT REQUEST

Original (for SUBMISSION) - printed on 18.06.1999 11:45:14 AM

0	For receiving Office use only	
0-1	International Application No.	
0-2	International Filing Date	
0-3	Name of receiving Office and "PCT International Application"	
0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.84 (updated 01.04.1999)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	European Patent Office (EPO) (RO/EP)
0-7	Applicant's or agent's file reference	WO24219
I	Title of invention	DIVERSITY TRANSMISSION METHOD AND SYSTEM
II	Applicant	
II-1	This person is:	applicant only
II-2	Applicant for	all designated States except US
II-4	Name	NOKIA TELECOMMUNICATIONS OY
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II-7	State of residence	FI
II-8	Telephone No.	+358 9 1807 0
II-9	Facsimile No.	+358 9 1807 496
III-1	Applicant and/or inventor	
III-1-1	This person is:	applicant and inventor
III-1-2	Applicant for	US only
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III-1-5	Address:	R. Adelaide Cabelte 14, V. Milhacos 2855 Corroios Portugal
III-1-6	State of nationality	PT
III-1-7	State of residence	PT

PCT REQUEST WO24219

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III-2	**Applicant and/or inventor**	
III-2-1	This person is:	applicant and inventor
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III-2-7	State of residence	FI
III-3	**Applicant and/or inventor**	
III-3-1	This person is:	applicant and inventor
III-3-2	Applicant for	US only
III-3-4	Name (LAST, First)	WICHMAN, Risto
III-3-5	Address:	Vilpurinkatu 1D A 20 FIN-00510 Helsinki Finland
III-3-6	State of nationality	FI
III-3-7	State of residence	FI
IV-1	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name (LAST, First)	PELLMANN, Hans-Bernd
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IV-2	**Additional agent(s)**	additional agent(s) with same address as first named agent
IV-2-1	Name(s)	TIEDTKE, Harro; BÜHLING, Gerhard; KINNE, Reinhard; GRAMS, Klaus; LINK, Annette; VOLLNHALS, Aurel; LESON, Thomas, Johannes, Alois; TRÖSCH, Hans-Ludwig; CHIVAROV, Georgi; GRILL, Matthias; KÜHN, Alexander; OSER, Andreas; BÖCKELEN, Rainer

PCT REQUEST

WO24219

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V	Designation of States		
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW SD SZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT	
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AL AM AT AU AZ BA BB BG BR BY CA CH&LI CN CU CZ DE DK EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG US UZ VN YU ZA ZW	
V-5	Precautionary Designation Statement In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.		
V-6	Exclusion(s) from precautionary designations	NONE	
VI	Priority claim	NONE	
VII-1	International Searching Authority Chosen	European Patent Office (EPO) (ISA/EP)	
VIII	Check list	number of sheets	electronic file(s) attached
VIII-1	Request	4	-
VIII-2	Description	20	-
VIII-3	Claims	6	-
VIII-4	Abstract	1	wo24219a.txt
VIII-5	Drawings	2	-
VIII-7	TOTAL	33	
	Accompanying Items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-16	PCT-EASY diskette	-	diskette

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VIII-18	Figure of the drawings which should accompany the abstract	1
VIII-19	Language of filing of the international application	English
IX-1	Signature of applicant or agent	
IX-1-1	Name (LAST, First)	PELLMANN, Hans-Bernd

FOR RECEIVING OFFICE USE ONLY

10-1	Date of actual receipt of the purported international application	
10-2	Drawings:	
10-2-1	Received	
10-2-2	Not received	
10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/EP
10-6	Transmittal of search copy delayed until search fee is paid	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	Date of receipt of the record copy by the International Bureau	

TBK TIEDTKE - BÜHLING - KINNE & PARTNER (GbR)

TBK-Patent POB 20 19 18 80019 München

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Dipl.-Ing. Stefan Klingele
Dipl.-Chem. Stefan Bühling
Dipl.-Ing. Ronald Roth

An das
Europäische Patentamt

80298 München

PCT chapter II

July 23, 2001

PCT Patent Application No.: PCT/EP99/04237
NOKIA NETWORKS OY
Our ref.: WO 24219 (F: 23.7. Eing.)

In response to the Written Opinion dated April 23, 2001.

Attached are submitted revised claims 1 to 30 which are to replace, for the purpose of the present international examination proceedings and without any binding or restrictive effect, the original set of claims.

The new claims 1 to 30 should be appropriate to meet the objections presented by the Examiner as far as deemed necessary from our side. In detail, claims 6 and 21 have been revised by canceling the „improvement" part. Proposed claims 18, 23 and 24 have been amended by inserting an „adapted to" clause.

A delimitation of the claims is presently not deemed appropriate.

With regard to the objection related to the description on page 8, line 12 to page 14, line 14 of the application specification, please note that these passages serve for explaining basic facts of the functioning of the embodiments. The „second diversity transmission scheme" is

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Dresdner Bank München Kto. 3939 844 BLZ 700 800 00
Postbank München Kto. 67043 804 BLZ 700 100 80
Dai-Ichi-Kangyo Bank München Kto. 8104233007 BLZ 300 207 00
Sanwa Bank Düsseldorf Kto. 500 047 BLZ 301 307 00
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subsequently described in the specification. Hence, no amendments of the specification appear to be necessary. The specification seems to be sufficiently clear so as not to cause any doubt on the claimed subject-matter.

The claimed subject-matter furthermore complies with all patentability requirements such as novelty and inventive step. As the Written Opinion does not contain any objections in this regard, and therefore appears to confirm novelty and inventive step of the claimed subject-matter, no further explanations appear to be necessary.

The new set of claims should be suitable for issuing an International Preliminary Examination Report confirming acceptability of the new set of claims.

Ronald Roth
Patentanwalt
TBK-Patent

Enclosure:
- Revised claims 1 to 30 (in triplicate)
- Revised claims 1 to 30 including marked amendments (for information purposes only)

Claims

1. A diversity transmission method for transmitting a transmission signal in a wireless communication system, comprising the steps of:

a) dividing said transmission signal into a plurality of subsignals;

b) applying an orthonormal transformation to said plurality of subsignals;

c) transmitting a first set of subsignals using a first diversity transmission scheme; and

d) transmitting a second set of said subsignals using a second diversity transmission scheme, said second diversity transmission scheme being different from said first diversity transmission scheme.

2. A method according to claim 1, wherein said first diversity transmission scheme is a space diversity transmission scheme.

3. A method according to claim 2, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

4. A method according to any one of the proceeding claims, wherein said second diversity transmission scheme is a frequency or time diversity scheme.

5. A method according to claim 4, wherein said second diversity transmission scheme is a complex diversity transform scheme.

6. A method according to claim 5, wherein said complex diversity transform scheme comprises an orthonormal transformation to a constellation which preserves Euclidean distances.

7. A method according to claim 5 or 6, wherein an original signal constellation represented as a matrix is used, and wherein each row of said matrix corresponds to a point in a multidimensional constellation.

8. A method according to claim 6 or 7, wherein said orthonormal transformation is achieved by a multiplication with a complex matrix.

9. A method according to claim 8, wherein each row of said complex matrix is orthogonal to any other row, and wherein the determinant of said matrix is equal to one.

10. A method according to claim 8 or 9, wherein said complex matrix is obtained based on an upperbound on the symbol error rate or based on a cutoff rate.

11. A method according to any one of claims 1 to 10, wherein said diversity transmission method is used in a downlink transmission of a cellular network.

12. A method according to any one of the preceding claims, wherein said transmission signal is a bit stream and said plurality of subsignals are substreams.

13. A method according to claim 12, wherein said transmission signal is a QPSK signal which can be represented by a vertex in a 2M-dimensional hyper-cube, where M denotes the dimension of a signal constellation.

14. A method according to any one of the preceding claims, wherein said wireless communication system is a WCDMA system.

15. A method according to any one of the preceding claims, wherein said first and second diversity transmission schemes comprise an open loop and/or a closed loop system.

16. A method according to any one of the preceding claims, wherein time slots of frequency carriers used in said second diversity transmission scheme are spaced apart to such a degree that independent fading is assured.

17. A method according to any one of the preceding claims, wherein said transmission signal comprises a signal constellation generated by optimizing the bit error rate and the peak to average ratio for a Rayleigh fading channel.

18. A transmitter for a diversity transmission system for transmitting a transmission signal in a wireless communication system, comprising:

a) dividing means **(10)** adapted to divide said transmission signal into a plurality of subsignals;

b) transforming means **(11)** adapted to apply an orthonormal transformation to said plurality of subsignals; and

c) transmitting means **(12)** adapted to transmit a first set of said subsignals using a first diversity transmission scheme, and a second set of said subsignals using a second diversity transmission scheme different from said first diversity transmission scheme.

19. A transmitter according to claim 18, wherein said first diversity transmission scheme is a space diversity transmission scheme using a plurality of transmission antennas **(A1-AM)**.

20. A transmitter according to claim 18 or 19, wherein said second diversity transmission scheme is a time or frequency diversity transmission scheme using a plurality of time slots or carrier frequencies.

21. A transmitter according to any one of claims 18 to 20, wherein said transforming means comprises a complex diversity transformation unit **(11)** arranged for performing an orthonormal transformation to a constellation which preserves Euclidean distances.

22. A transmitter according to any one of claims 18 to 21, wherein said transmitter is arranged in a WCDMA base station.

23. A receiver for a diversity transmission system, for receiving a transmission signal in a wireless communication system, comprising:

a) receiving means **(40, 4110, 4111, 4120, 4121, 41M0, 41M1, 421, 422,...42M)** adapted to receive a transmission signal comprising a first set of subsignals transmitted by using a first diversity transmission scheme, and a second set of subsignals transmitted by using a second diversity transmission scheme different from said first diversity transmission scheme; and

b) decoding means **(43)** adapted to decode said transmission signal by deciding on a maximum likelihood between said

received subsignals and corresponding estimated subsignals.

24. A receiver according to claim 23, further comprising channel estimation means **(44)** adapted to perform a channel estimation used for obtaining said corresponding estimated subsignals.

25. A receiver according to claim 23 or 24, wherein said first diversity transmission scheme is a space diversity transmission scheme.

26. A receiver according to claim 25, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

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28. A receiver according to claim 27, wherein said time or frequency diversity scheme is a complex diversity transformation scheme.

29. A receiver according to any one of claims 23 to 28, wherein said transmission signal is a QPSK signal and said receiving means comprises a bank of 2M correlators, wherein M denotes the number of transmission antennas used in said first diversity transmission scheme.

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Claims

1. A diversity transmission method for transmitting a transmission signal in a wireless communication system, comprising the steps of:

a) dividing said transmission signal into a plurality of subsignals;

b) applying an orthonormal transformation to said plurality of subsignals;

c) transmitting a first set of subsignals using a first diversity transmission scheme; and

d) transmitting a second set of said subsignals using a second diversity transmission scheme, said second diversity transmission scheme being different from said first diversity transmission scheme.

2. A method according to claim 1, wherein said first diversity transmission scheme is a space diversity transmission scheme.

3. A method according to claim 2, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

4. A method according to any one of the proceeding claims, wherein said second diversity transmission scheme is a frequency or time diversity scheme.

5. A method according to claim 4, wherein said second diversity transmission scheme is a complex diversity transform scheme.

6. A method according to claim 5, wherein said complex diversity transform scheme comprises an orthonormal transformation to a constellation which preserves Euclidean distances ~~but improves the resistances to fading~~.

7. A method according to claim 5 or 6, wherein an original signal constellation represented as a matrix is used, and wherein each row of said matrix corresponds to a point in a multidimensional constellation.

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9. A method according to claim 8, wherein each row of said complex matrix is orthogonal to any other row, and wherein the determinant of said matrix is equal to one.

10. A method according to claim 8 or 9, wherein said complex matrix is obtained based on an upperbound on the symbol error rate or based on a cutoff rate.

11. A method according to any one of claims 1 to 10, wherein said diversity transmission method is used in a downlink transmission of a cellular network.

12. A method according to any one of the preceding claims, wherein said transmission signal is a bit stream and said plurality of subsignals are substreams.

13. A method according to claim 12, wherein said transmission signal is a QPSK signal which can be represented by a vertex in a 2M-dimensional hyper-cube, where M denotes the dimension of a signal constellation.

14. A method according to any one of the preceding claims, wherein said wireless communication system is a WCDMA system.

15. A method according to any one of the preceding claims, wherein said first and second diversity transmission schemes comprise an open loop and/or a closed loop system.

16. A method according to any one of the preceding claims, wherein time slots of frequency carriers used in said second diversity transmission scheme are spaced apart to such a degree that independent fading is assured.

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a) dividing means **(10)** adapted to ~~for~~ divide~~ing~~ said transmission signal into a plurality of subsignals;

b) transforming means **(11)** adapted to ~~for~~ apply~~ing~~ an orthonormal transformation to said plurality of subsignals; and

c) transmitting means **(12)** adapted to ~~for~~ transmit~~ting~~ a first set of said subsignals using a first diversity transmission scheme, and a second set of said subsignals using a second diversity transmission scheme different from said first diversity transmission scheme.

19. A transmitter according to claim 18, wherein said first diversity transmission scheme is a space diversity transmission scheme using a plurality of transmission antennas **(A1-AM)**.

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21. A transmitter according to any one of claims 18 to 20, wherein said transforming means comprises a complex diversity transformation unit **(11)** arranged for performing an orthonormal transformation to a constellation which preserves Euclidean distances ~~but improves resistance to fading of an original signal constellation obtained from said dividing means **(10)**~~.

22. A transmitter according to any one of claims 18 to 21, wherein said transmitter is arranged in a WCDMA base station.

23. A receiver for a diversity transmission system, for receiving a transmission signal in a wireless communication system, comprising:

a) receiving means **(40, 4110, 4111, 4120, 4121, 41M0, 41M1, 421, 422,...42M)** adapted to ~~for~~ receive~~ing~~ a transmission signal comprising a first set of subsignals transmitted by using a first diversity transmission scheme, and a second set of subsignals transmitted by using a second diversity transmission scheme different from said first diversity transmission scheme; and

b) decoding means **(43)** adapted to ~~for~~ decode~~ing~~ said transmission signal by deciding on a maximum likelihood between said received subsignals and corresponding estimated subsignals.

24. A receiver according to claim 23, further comprising channel estimation means **(44)** adapted to ~~for~~ perform~~ing~~ a channel estimation used for obtaining said corresponding estimated subsignals.

25. A receiver according to claim 23 or 24, wherein said first diversity transmission scheme is a space diversity transmission scheme.

26. A receiver according to claim 25, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

27. A receiver according to any one of claims 23 to 26, wherein said second diversity scheme is a time or frequency diversity scheme.

28. A receiver according to claim 27, wherein said time or frequency diversity scheme is a complex diversity transformation scheme.

29. A receiver according to any one of claims 23 to 28, wherein said transmission signal is a QPSK signal and said receiving means comprises a bank of 2M correlators, wherein M denotes the number of transmission antennas used in said first diversity transmission scheme.

30. A receiver according to any one of claims 23 to 29, wherein said receiver is arranged in a mobile WCDMA terminal of a cellular network.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
W024219		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 99/ 04237	18/06/1999	
Applicant		
NOKIA NETWORKS OY		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

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2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

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6. The figure of the drawings to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] None of the figures.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International Application No
PC[redacted] 99/04237

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/06 H04L1/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 832 044 A (SOUSA ELVINO S ET AL) 3 November 1998 (1998-11-03) cited in the application column 3, line 18 -column 4, line 33 column 5, line 1 - line 50 column 6, line 25 -column 11, line 19	1-4, 11-20, 22-27, 29,30
A	column 13, line 14 -column 14, line 29	5-9,21, 28

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-/—

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search	Date of mailing of the international search report
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European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Lõpez-Pérez, M-C

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Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DASILVA V M ET AL: "FADING-RESISTANT MODULATION USING SEVERAL TRANSMITTER ANTENNAS" IEEE TRANSACTIONS ON COMMUNICATIONS,US,IEEE INC. NEW YORK, vol. 45, no. 10, 1 October 1997 (1997-10-01), pages 1236-1244, XP000723121 ISSN: 0090-6778 cited in the application page 1236, left-hand column, line 18 -page 1240, left-hand column, line 14	1,4-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5832044 A	03-11-1998	NONE	

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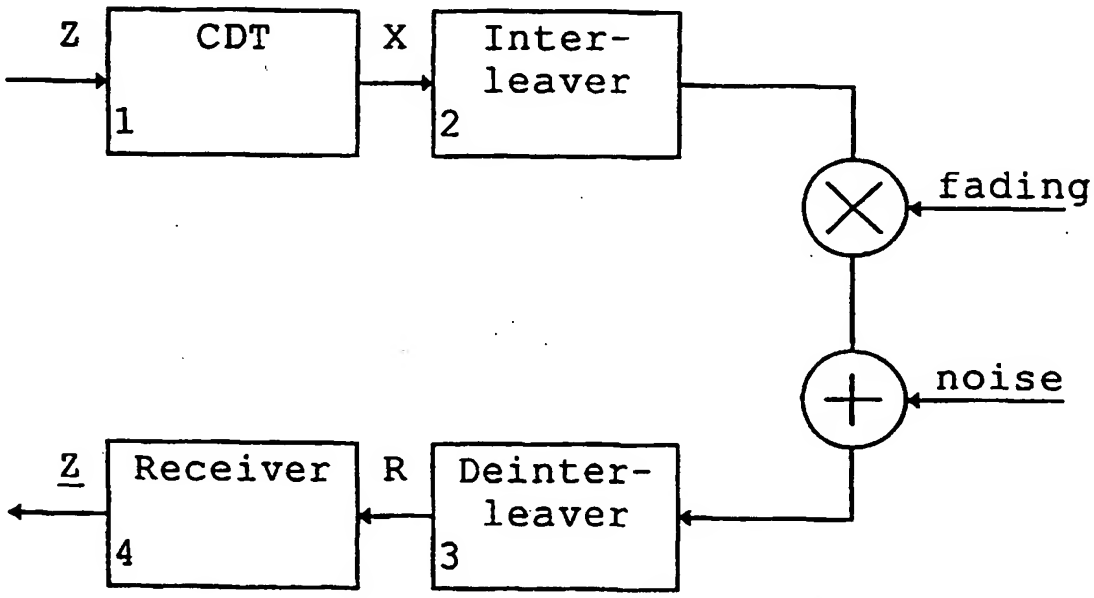
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DIVERSITY TRANSMISSION METHOD AND SYSTEM



(57) Abstract: The present invention relates to a diversity transmission method and system, wherein a transmission signal is divided into a plurality of subsignals. A first set of the subsignals in transmitted using a first diversity transmission scheme, and a second set of said subsignals is transmitted using a second diversity transmission scheme. Thus, a joint coordination between different types of diversity transmission schemes is proposed so as to achieve a significant capacity increase at a moderate complexity.

WO 00/79701 A1

DIVERSITY TRANSMISSION METHOD AND SYSTEM

FIELD OF THE INVENTION

The present invention relates to a diversity transmission method and system for transmitting a transmission signal in a wireless communication system, such as the Universal Mobile Telecommunications System (UMTS).

BACKGROUND OF THE INVENTION

Wideband Code Division Multiple Access (WCDMA) has been chosen as the radio technology for the paired bands of the UMTS. Consequently, WCDMA is the common radio technology standard for third-generation wide-area mobile communications. WCDMA has been designed for high-data services and, more particularly, Internet-based packet-data offering up to 2 Mbps in indoor environments and over 384 kbps for wide-area applications.

The WCDMA concept is based on a new general structure for all layers built on technologies such as packet-data channels and service multiplexing. The new concept also includes pilot symbols and a time-slotted structure which has led to the provision of adaptive antenna arrays which direct antenna beams at users to provide maximum range and minimum interference. This is also crucial when implementing wideband technology where limited radio spectrum is available.

The uplink capacity of the proposed WCDMA systems can be enhanced by various techniques including multi-antenna reception and multi-user detection or interference

cancellation. Techniques that increase the downlink capacity have not been developed with the same intensity. However, the capacity demand due to the projected data services (e.g. Internet) burdens more heavily the downlink channel. Hence, it is important to find techniques that improve the capacity of the downlink channel.

Bearing in mind the strict complexity requirements of terminals, and the characteristics of the downlink channel, the provision of multiple receive antennas is not a desired solution to the downlink capacity problem. Therefore, alternative solutions have been proposed suggesting that multiple antennas or transmit diversity at the base station will increase downlink capacity with minor increase of complexity in terminal implementation.

In third-generation mobile radio systems in general and in particular for WCDMA systems, the downlink capacity is a bottleneck. This is due to fading of the transmitted signal, wherein the amplitude of the signal is subjected to random fluctuations. To overcome this situation, transmitter antenna diversity has been proposed for the downlink direction. Known transmitter diversities schemes can be divided into two categories, open loop systems and closed loop systems. The difference between the open loop and the closed loop systems is that the former sends a feedforward or training information, in order to provide an information about the channel at the receiver. On the other hand, the latter system gets knowledge of the channel at the transmitter side by virtue of a feedback path from the receiver to the transmitter. Selective Transmit Diversity (STD) is an example of a closed loop system which is easy to implement in digital cellular systems due to the presence of a permanent feedback connection. Furthermore,

systems that employ either of the two categories of transmitter diversity are known.

The prior art diversity systems are described e.g. in document US-A-5,832,044 and in the publications "Fading Resistant Modulation Using Several Transmitter Antennas" by Sousa et al., IEEE Trans. On Communications, p.p. 1236-1244, Oct. 1997, and "Diversity Transform for Fading Channels", by D. Rainish, IEEE Trans. On Communications, p.p. 1653-1661, Dec. 1996.

In the above prior art systems, all components of a constellation vector (super symbol) are transmitted via either of different antennas, different carrier frequencies, or diferent time slots. However, since the optimum decoding complexity grows exponentially with the number of components of the constellation vector, the transmission capacity is limited. Moreover, a high peak to average ratio results from an increased constellation size.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a diversity transmission method and system, by means of which the transmission capacity can be increased.

This object is achieved by a diversity transmission method for transmitting a transmission signal in a wireless communication system, comprising the steps of:
dividing the transmission signal into a plurality of subsignals;
applying an orthonormal transformation to said plurality of subsignals;

transmitting a first set of the subsignals using a first diversity transmission scheme; and
transmitting a second set of the subsignals using a second diversity transmission scheme, the second diversity transmission scheme being different from the first diversity transmission scheme.

Furthermore, the above object is achieved by a transmitter for a diversity transmission system for transmitting transmission signal in a wireless communication system, comprising:
dividing means for dividing the transmission signal into a plurality of subsignals; and
transforming means for applying an orthonormal transformation to said plurality of subsignals;
transmitting means for transmitting a first set of the subsignals using a first diversity transmission scheme, and a second set of the subsignals using a second diversity transmission scheme different from the first diversity transmission scheme.

Additionally, the above object is achieved by a receiver for a diversity transmission system, for receiving a transmission signal in a wireless communication system, comprising:
receiving means for receiving a transmission signal comprising a first set of subsignals transmitted by using a first diversity transmission scheme, and a second set of subsignals transmitted by using a second diversity transmission scheme different from the first diversity transmission scheme; and
decoding means for decoding the transmission signal by deciding on a maximum likelihood between the received subsignals and corresponding estimated subsignals.

Accordingly, a joint coordination between different diversity transmission types is provided, which results in a significant capacity increase as compared to previous transmitter diversity schemes based on multidimensional fading resistant constellations. Thus, an optimum detection method can be used which makes the optimum decoding complexity grow linear with the dimension of the constellations.

In a cellular network, a fading resistant transmission scheme can be provided, where a base station uses M antennas or/and M time slots (regardless of the use a frame orientated power control) or/and M carrier frequencies (for narrow band systems), wherein M denotes the dimension of the signal constellation.

Preferably, the first diversity transmission scheme is a space diversity transmission scheme, such as a selective transmitter antenna diversity (STD). The second diversity transmission scheme may be a frequency or time diversity scheme. The original signal constellation may be represented as a matrix, wherein each row of the matrix corresponds to a point in a multidimensional constellation. In particular, a complex diversity transformation may be used, wherein an orthonormal transformation to a constellation which preserves Euclidean distances but improves the resistance to fading may be performed. The orthonormal transformation may be achieved by a multiplication with a complex matrix. Preferably, each row of the complex matrix is orthogonal to any other row, wherein the determinant of the matrix is equal to one. The complex matrix may be obtained based on the upper bound on the symbol error rate or based on the cut off rate.

Preferably, the diversity transmission method is used in the downlink direction of a cellular network.

The transmission signal may be a bit stream and the plurality of subsignals may be substreams. In particular, the transmission signal may be a PSK signal, preferably a QPSK signal which can be represented by a vertex in a 2M-dimensional hyper-cube, where M denotes the dimension of the signal constellation. In this case, the receiving means may comprise a bank of 2M correlators, wherein M denotes the number of transmission antennas used in the first diversity transmission scheme.

The wireless communication system may be a WCDMA system, wherein the transmitter may be arranged in a WCDMA base station and the receiver in a WCDMA mobile station.

Furthermore, the first and second diversity transmission schemes may comprise an open loop and/or a closed loop system.

Preferably, time slots of frequency carriers used in the second diversity transmission scheme are spaced apart to such a degree that independent fading is assured. Thereby, the transmissions can be coordinated to mitigate the effects of multi-path Rayleigh fading, and the receiver can recover the entire M-dimensional transmitted signal constellation or vector, as long as the signal energy of at least one coordinate is large enough. In particular, the M-dimensional signal constellation may be generated by optimizing the bit error rate and the peak to average ratio for a Rayleigh fading channel. The bit-error-rate may be further improved by using the STD scheme. This scheme

offers a significant performance improvement over the conventional single antenna N-PSK scheme and other known M-dimensional fading resisting constellations for a given bit-error-rate. In the downlink direction of a cellular network, a significant capacity increase is achieved as compared to uncoded N-PSK and other known M-dimensional fading resistant constellations.

Preferably, the transmitting means comprises a complex diversity transformation unit arranged for performing an orthonormal transformation to a constellation which preserves Euclidean distances but improves resistance to fading of an original signal constellation obtained from the dividing means.

Furthermore, the receiver may comprise channel estimation means for performing a channel estimation used for obtaining the corresponding estimated subsignal.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the present invention will be described in greater detail on the basis of a preferred embodiment which reference to the accompanying drawings, in which:

Fig. 1 shows a principle block diagram of a transmission system according to the present invention,

Fig. 2 shows a principle block diagram of a transmitter according to a preferred embodiment of the present invention; and

Fig. 3 shows a principle block diagram of a receiver according to a preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following, the preferred embodiment of the present invention will be described on the basis of a downlink transmission between a base station and a mobile station of a cellular network such as the UMTS.

In spectrally efficient transmitter antenna, frequency and time diversity schemes, the information bit stream is divided into substreams, wherein each substream is transmitted over a different antenna, a different frequency, or a different time slot. Taking jointly, the transmission of a set of symbols can be viewed as the transmission of a super symbol. In the case of a QPSK transmission, the super symbol can be represented by a vertex in a 2M-dimensional hyper-cube, where M denotes the number of antennas, frequencies, or time slots.

According to the preferred embodiment of the present invention, a wideband system is considered such that the use of multiple carriers is not appropriate and will not be described in detail. However, the present invention is not restricted to wideband systems.

The WCDMA system operates at a low signal to noise ratio. Therefore, optimal signaling constellations for N-PSK modulations which are fading resistant at low signal to noise ratios are required.

The transmitter transmits a sequence of symbols from a fixed symbol alphabet. As already mentioned, each symbol may be represented as a vector in an M-dimensional vector space. Thus, each vector has M components. According to the present invention, the transmission of the M components is combined in different antennas and different time slots. Furthermore, in case of narrowband systems, a combination with different frequency carriers can be used for transmitting the M components. In particular, the constellation is obtained from an M-dimensional hyper-cube based on an orthogonal transformation. However, the separation between constellation points may be further maximized and none of the points are superimposed. The result is a much better performance over fading channels.

Fig. 1 shows a principle block diagram of the diversity transmission system according to a present invention. The system comprises M transmitter antennas (not shown) for transmitting a transmission signal from a base station to a mobile terminal, and a single receiver antenna (not shown). Thus, the received base band signal is obtained by the following equation:

$$r(t) = \sum_{i=1}^{M} x_i \, s_i(t) \sum_{j=1}^{L} (\alpha_i^j + n_i^j(t)) \qquad (1)$$

Between the receiver antenna and each transmitter antennas there are L multi-paths, wherein the symbol α_i^j denotes the Rayleigh fading of the j-th multi-path of the i-th transmit antenna at the receiver, x_i represents the N-PSK transformed signal on the i-th antenna, $s_i(t)$ denotes a bandlimited pulse, where $s_i(t)$, $s_k(t)$ are assumed to be

orthogonal for i ≠ k. similarly, n_i^j(t) denotes the added AWGN (Additive Wide Gaussian Noise) with power spectral density No/2.

An independent fading can be assumed if the transmitter antennas or time slots of frequency carriers are sufficiently spaced apart.

According to the present invention, the receiver 4 is capable of estimating the fading amplitude of each link. This is possible, if the fading amplitudes vary slowly over time. If the fading amplitudes vary quickly over time, it is expected that the receiver performance degrades due to estimation errors.

In the transmitter, a complex diversity transformation unit 1 is provided for performing a diversity transformation of an input signal constellation set which can be represented as a matrix. The interleaver 2 and deinterleaver 3 shown in Fig. 1 are not specific to the diversity transformation. They relate to the usual interleaving required for systems with forward error correction capabilities. In such systems, it is necessary to assure that fading amplitudes are uncorrelated. The delay introduced by the interleaver depends on the giving service and the general fading characteristics.

The original signal constellation is represented as a matrix Z, where each row corresponds to a point in the M-dimensional constellation corresponding to M input (encoded) symbols. Given the M-dimensional constellation of $Q = N^M$ points, a transformation is applied by the complex diversity transformation unit 1, such that the Euclidean

distances between the constellation points are preserved, but the constellations resistance to fading is improved. The requirement that the transformation preserves the Euclidean distances between points and norms is imposed to thereby assure that the performance of the new constellation in the AWGN channel is not degraded. Such orthonormal transformations are called isometries.

For example, in case of a BPSK or a QPSK system, the original constellations for M = 2 are given by

$$Z_{BPSK} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \\ -1 & -1 \\ -1 & 1 \end{bmatrix}, \quad Z_{QPSK} = \begin{bmatrix} 1+j & 1+j \\ 1+j & 1-j \\ 1+j & -1-j \\ 1+j & -1+j \\ 1-j & 1+j \\ 1-j & 1-j \\ 1-j & -1-j \\ 1-j & -1+j \\ -1-j & 1+j \\ -1-j & 1-j \\ -1-j & -1-j \\ -1-j & -1+j \\ -1+j & 1+j \\ -1+j & 1-j \\ -1+j & -1-j \\ -1+j & -1+j \end{bmatrix}$$

These constellation matrixes are multiplied in the complex diversity transformation unit 1 by an orthonormal M x M matrix A_M to thereby preserve the distance between vectors, and the energy. The transformed constellation X is given by

$$X = ZA_M \qquad (2)$$

To be orthonormal, the complex matrix AM must fulfill the following conditions:

(1) each row is orthogonal to any other row;

(2) the determinant of the matrix is equal to one.

According to the invention, the orthonormal complex matrixes for M = 2 and M = 2^n are generally given by

$$\overline{A_2} = \frac{A_2}{|A_2|^{1/M}}, \quad A_2 = \begin{bmatrix} e^{j\phi} & e^{-j\phi} \\ -e^{-j\phi} & e^{j\phi} \end{bmatrix}, \quad |A_2| = \det(A_2) = 2\cos(2\phi)$$

$$\overline{A_{2n}} = \frac{A_{2n}}{|A_{2n}|^{1/M}}, \quad A_{2n} = \begin{bmatrix} A_n & A_n \\ A_n & -A_n \end{bmatrix}, \quad |A_{2n}| = \det(A_{2n}) = f(\phi) \tag{3}$$

wherein ϕ denotes the angle that must be chosen in order to minimize the error probability in fading channels. This, however, constitutes an untractable problem in mathematics. Therefore, two other suboptimal approaches can be used, i.e. the upperbound on the symbol error rate and the cutoff rate, wherein the vector is assumed to be part of a random code with infinite length in which all vectors are independent. The upperbound on the symbol error rate is described e.g. in "Introduction to Trellis-Coded Modulation with Applications" by E. Biglieri et al., Macmillan Pub., 1993, chapter 9, and is given by

$$P(\underline{x} \rightarrow \underline{\hat{x}}) = \operatorname{Min}_{\underline{x} \neq \underline{\hat{x}}} \forall(x,\underline{\hat{x}}) \prod_{i=1}^{M} \frac{1}{1 + \frac{E_S}{4N_0} |x_i - \underline{\hat{x}_i}|^2} \tag{4}$$

and the cutoff rate is described e.g. in "Diversity Transform for Fading Channels" by D. Rainish, IEEE

Transaction On Communications, p.p. 1653-1661, Dec. 1996. and is given by

$$R_0 = \log_2 N - \frac{1}{M}\log_2 \left[\forall(x,\underline{x}) \prod_{x \neq \underline{x}}^{M} \frac{1}{1+\frac{E_s}{4N_0}\left|x_i - \underline{x_i}\right|^2} \right] \qquad (5)$$

wherein N denotes the dimension of the modulation, e.g. N = 4 for QPSK modulation.

Comparing the two above equations (4) and (5) it can be seen that they are somehow related. The main difference lies in the minimum operator only used in the bit error rate upperbound. This criteria is optimum for a use of the scheme in a high signal to noise ratio environment. In this invention, however, the interesting signal to noise ratio (SNR) comprises small values of E_s/N_0. Thus, the cutoff rate is preferably chosen, because it considers all pairs of $(\mathbf{x},\underline{\mathbf{x}})$, wherein $\mathbf{x}$ indicates the transmitted vector and $\underline{\mathbf{x}}$ denotes the super symbol picked up in the receiver 4. There are certain values of ϕ which cannot be used. Those values must be avoided. For N-PSK modulations, the acceptable angles are defined by

$$\phi \neq \pi/N \ , \ \phi < \pi/N \qquad (6)$$

To be fading resistant, any two points of the signal constellation should have a large number of components which differ significantly. For every M and in particular for M = 2, it is important that the determinant of the complex matrix A_M is minimized, such that a large number of components differ significantly and a better performance of

the scheme is achieved. However, to obtain low determinant values, the limit given by equation (6) must be approached, which originates signaling constellation points close to zero and high peak to average amplitude ratios. The search for an optimal angle ϕ can be made exhaustively for small discredisation intervals, e.g. 1°, because only one angle has to be optimized. The optimal interval for the angle ϕ is $[\pi/8, \pi/6]$. In the preferred embodiment, an angle $\phi = \pi/6$ has been chosen. For this angle, the determinant of the complex matrix A_2 is equal to one.

In general, the performance results obtained by a complex orthogonal matrix are better than those obtained by a real orthonormal matrix for M = 2 and M = 4.

According to the preferred embodiment of the present invention, a selective transmitter antenna diversity (STD) is combined with the complex diversity transformation (CDT). Thereby, a diversity of any order can be obtained. For instance, a diversity of order 8 can be obtained e.g. by using a complex diversity transformation of order 4 (time diversity) and an STD with 2 antennas, or by using a complex diversity transformation of order 2 and a STD diversity with 4 antennas.

Fig. 2 shows a principal block diagram of a transmitter which may be used in a base station and in which a combined CDT and STD are performed. According to Fig. 2 the transmitter comprises a coding unit 10 arranged for generating the signal constellation matrix Z based on received input symbols to be transmitted to a mobile station. The generated constellation matrix Z is supplied to a complex diversity transformation unit 11 which

performs a multiplication of the constellation matrix Z with the orthonormal matrix A_M, as defined in the equation (2). In particular, the coding unit 10 and the complex diversity transformation unit 11 may be realized by corresponding digital processing circuits or by a central processing unit controlled on the basis of a corresponding control program. The obtained transformed signal constellation matrix X is supplied to a transmitting unit Tx 12, wherein each column of the transformed constellation matrix X corresponds to a respective one of a plurality of transmission antennas A1, A2,...AM, such that a first set of subsignals or subsymbols (correspoonding to the matrix columns) are transmitted via respective different ones of the transmission antennas A1 to AM, and a second set of subsignals or subsymbols (corresponding to matrix rows) are transmitted in respective different time slots.

Fig. 3 shows a corresponding receiver of the transmission system, which may be provided in a mobile station of a cellular network. In the present case, a QPSK modulation is used for the transmission, wherein the receiver is a QPSK optimum receiver consisting of a bank of 2M integrators (or correlators) 4110, 4111, 4120, 4121,...41M0, 41M1.

The radio signals transmitted from the transmission antennas A1 to AM are received via a single receiving antenna by a receiving unit Rx 40 of the receiver, and an in-phase component and a quadrature component are obtained by multiplying the received signal with a sine signal and a cosine signal, respectively, of the carrier frequency. The in-phase and quadrature components are each supplied to M processing channels, where a detection is performed based on a multiplication with respective bandlimited pulse

signals $s_1(t)$, $s_2(t)$, ...$s_M(t)$. The detected received signals are supplied to respective ones of the integrators 4110 to 41M1. In the present preferred embodiment, only coherent demodulators are considered. For a single path Rayleigh fading channel (L = 1, subscript j dropped), the output of the i-th integrator (correlator) is given by

$$y_i = \int_0^T r(t)s_i(t)dt = \alpha_i x_i E_S + \eta_i, \quad E_S = \int_0^T s_i^2(t)dt \tag{7}$$

wherein η_i ($1 \leq i \leq M$) denotes an uncorrelated zero-mean Gaussian random variable with variance N_0E_s, and wherein T denotes the time period of a received symbol. Thus, most of the energy of the signal $s_i(t)$ is contained in the interval [0, T].

The outputs of the integrators 4110, 4120,..., 41M0 of the in-phase component and the integrators 4111, 4121,..., 41M1 of the quadrature component are combined by respective combining circuits 421 to 42M which output the components y_1 to y_M of the received vector $\mathbf{y}$. The received vector $\mathbf{y} = (y_1,...y_M)$ is supplied to a decision device such as a minimum distance decoder 43 which estimates the transmitted vector $\mathbf{x} = (x_1,...x_M)$. Furthermore, a channel estimator 44 is provided for estimating fading amplitudes α_i and for supplying the estimated fading amplitudes α_i to the minimum distance decoder 43. The minimum distance decoder 43 selects a super symbol $\underline{\mathbf{x}} = (\underline{x}_1,...\underline{x}_M)$ which is an element of an M-dimensional constellation. The selection is performed in such a manner that the following equation is satisfied

$$Min \sum_{i=1}^{M} \left| y_i / E_S - \alpha_i \underline{x} \right|^2, \quad \forall (x, \underline{x}) \tag{8}$$

A symbol detecting error occurs, when $\mathbf{x} \neq \underline{\mathbf{x}}$. Thus, the receiver is a maximum likelihood receiver arranged to choose between N^M (N is the size of the alphabet) possible different combinations of $(\mathbf{x}, \underline{\mathbf{x}})$.

The communication links between the transmitting antennas A1 to AM and the receiving antenna are not generally line-of-sight links. In general, a multi-path Rayleigh fading model is assumed. The fading amplitudes α_i^j are modelled as independent and identically distributed Rayleigh random variables, wherein the probability density function is given by

$$f(\alpha) = 2\alpha \exp(-\alpha^2), \quad \alpha \geq 0 \tag{9}$$

It is to be noted that the interleaver 2 and the deinterleaver 3 shown in Fig. 1 and required for forward error correction capabilities are not shown in the transmitter and the receiver according to Figs. 2 and 3, respectively.

The present invention is not restricted to a combination of CDT with STD. Any combination of different diversity schemes can be used, wherein a combination of a space diversity scheme such as STD with time diversity schemes such as CDT, RDT (Real Diversity Transformation), may be applied.

The reference probability of the bit error rate for uncoded wideband systems is $P_b = 4 \times 10^{-2}$. For this reference P_b, a gain of 2dB can be achieved between CDT and RDT without STD. If STD is combined with other diversity transformations, a gain of 1.5 dB is achieved between CDT and RDT. Compared to a single STD, the combination of CDT with STD provides an additional gain of 2.1 dB. For all diversity transformations, an optimal angle $\phi = \pi/6$ has been obtained.

For higher diversity orders, such as M = 4, CDT continues to provide additional gain over RDT with and without STD, however, now these gains are not so significant. When CDT (with diversity order 2) and STD (with diversity order 2) are combined, the equivalent diversity order is 4. Another way to achieve this diversity order is CDT with diversity order 4. The comparison between these two cases indicates that CDT + STD leads to a better performance and should therefore be chosen.

The minimum distance decoder 43 shown in Fig. 3 is able to avoid the exponential growth of the decoding complexity, when the minimum distance is chosen between $(\mathbf{x}, \underline{\mathbf{x}})$, as given by equation (8). This can be gathered from the following equation

$$\left|y_1/E_s - \alpha_1 x_1\right|^2, \forall(x_1, \underline{x}_1) \cdot \left|y_2/E_s - \alpha_2 x_2\right|^2, \forall(x_2, \underline{x}_2) \cdots \left|y_M/E_s - \alpha_M \underline{x}_M\right|^2, \forall(x_M, \underline{x}_M) \qquad (10)$$

Since the metrics is positive and additive, it is better to compute the minimum distance individually for each link i and decide individually on the transmitted symbols.

As an example, a 4-PSK signal with diversity order M = 4 is considered. Based on the equation (10) the following result is obtained.

$$d_1=|y_1/E_S-a_1(1+j)|^2, d_2=|y_1/E_S-a_1(1-j)|^2, d_3=|y_1/E_S-a_1(-1-j)|^2, d_4=|y_1/E_S-a_1(-1+j)|^2 \quad (11)$$

Accordingly, the minimum is chosen for all $d_n (1 \leq n \leq N)$, which leads to the decision on x_1. Next, the decision is made as to x_2, based on the minimum of N metrics, and so on, until a decision is made on x_M, also based on N metrics, wherein N = 4. Thus, M decisions are performed based on N metrics. Thus, N x M metrics have to be computed, instead of N^M as in the known solutions.

The present inventions can be implemented in a variety of ways. A combination of spectrally efficient transmitter time diversity of order M_1 with a selective transmitter antenna diversity (STD) of order M_2 is preferred to achieve a total diversity order of $M = M_1 \times M_2$. For narrowband systems, the present invention can be implemented as a spectrally efficient transmitter frequency diversity scheme in combination with STD, so as to increase the order of the diversity.

The present invention can be applied to improve the performance of the physical layer of the UMTS UTRA/FDD (UMTS Radio Access/Frequency Division Duplex) components. Alternatively, it may be implemented in the physical layer of UMTS UTRA/TDD (Time Division Duplex) components. In general, the present invention can be implemented in any transmission link of any digital cellular network to

thereby increase the capacity of that link. Therefore, the above description of the preferred embodiment and the accompanying drawings are only intended to illustrate the present invention. The preferred embodiment of the invention may vary within the scope of the attached claims.

In summary, the present invention relates to a diversity transmission method and system, wherein a transmission signal is divided into a plurality of subsignals. A first set of the subsignals is transmitted using a first diversity transmission scheme, and a second set of the subsignals is transmitted using a second diversity transmission scheme. Thus, a joint coordination between different types of diversity transmission schemes is proposed so as to achieve a significant capacity increase at a moderate complexity.

Claims

1. A diversity transmission method for transmitting a transmission signal in a wireless communication system, comprising the steps of:

a) dividing said transmission signal into a plurality of subsignals;

b) applying an orthonormal transformation to said plurality of subsignals;

c) transmitting a first set of subsignals using a first diversity transmission scheme; and

d) transmitting a second set of said subsignals using a second diversity transmission scheme, said second diversity transmission scheme being different form said first diversity transmission scheme.

2. A method according to claim 1, wherein said first diversity transmission scheme is a space diversity transmission scheme.

3. A method according to claim 2, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

4. A method according to any one of the proceeding claims, wherein said second diversity transmission scheme is a frequency or time diversity scheme.

5. A method according to claim 4, wherein said second diversity transmission scheme is a complex diversity transform scheme.

6. A method according to claim 5, wherein said complex diversity transform scheme comprises an orthonormal

transformation to a constellation which preserves Euclidean distances but improves the resistances to fading.

7. A method according to claim 5 or 6, wherein an original signal constellation represented as a matrix is used, and wherein each row of said matrix corresponds to a point in a multidimensional constellation.

8. A method according to claim 6 or 7, wherein said orthonormal transformation is achieved by a multiplication with a complex matrix.

9. A method according to claim 8, wherein each row of said complex matrix is orthogonal to any other row, and wherein the determinant of said matrix is equal to one.

10. A method according to claim 8 or 9, wherein said complex matrix is obtained based on an upperbound on the symbol error rate or based on a cutoff rate.

11. A method according to any one of claims 1 to 10, wherein said diversity transmission method is used in a downlink transmission of a cellular network.

12. A method according to any one of the preceding claims, wherein said transmission signal is a bit stream and said plurality of subsignals are substreams.

13. A method according to claim 12, wherein said transmission signal is a QPSK signal which can be represented by a vertex in a 2M-dimensional hyper-cube, where M denotes the dimension of a signal constellation.

14. A method according to any one of the preceding claims, wherein said wireless communication system is a WCDMA system.

15. A method according to any one of the preceding claims, wherein said first and second diversity transmission schemes comprise an open loop and/or a closed loop system.

16. A method according to any one of the preceding claims, wherein time slots of frequency carriers used in said second diversity transmission scheme are spaced apart to such a degree that independent fading is assured.

17. A method according to any one of the preceding claims, wherein said transmission signal comprises a signal constellation generated by optimizing the bit error rate and the peak to average ratio for a Rayleigh fading channel.

18. A transmitter for a diversity transmission system for transmitting a transmission signal in a wireless communication system, comprising:

a) dividing means **(10)** for dividing said transmission signal into a plurality of subsignals;

b) transforming means **(11)** for applying an orthonormal transformation to said plurality of subsignals; and

c) transmitting means **(12)** for transmitting a first set of said subsignals using a first diversity transmission scheme, and a second set of said subsignals using a second diversity transmission scheme different from said first diversity transmission scheme.

19. A transmitter according to claim 18, wherein said first diversity transmission scheme is a space diversity transmission scheme using a plurality of transmission antennas **(A1-AM)**.

20. A transmitter according to claim 18 or 19, wherein said second diversity transmission scheme is a time or frequency diversity transmission scheme using a plurality of time slots or carrier frequencies.

21. A transmitter according to any one of claims 18 to 20, wherein said transforming means comprises a complex diversity transformation unit **(11)** arranged for performing an orthonormal transformation to a constellation which preserves Euclidean distances but improves resistance to fading of an original signal constellation obtained from said dividing means **(10)**.

22. A transmitter according to any one of claims 18 to 21, wherein said transmitter is arranged in a WCDMA base station.

23. A receiver for a diversity transmission system, for receiving a transmission signal in a wireless communication system, comprising:

a) receiving means **(40, 4110, 4111, 4120, 4121, 41M0, 41M1, 421, 422,...42M)** for receiving a transmission signal comprising a first set of subsignals transmitted by using a first diversity transmission scheme, and a second set of subsignals transmitted by using a second diversity transmission scheme different from said first diversity transmission scheme; and

b) decoding means **(43)** for decoding said transmission signal by deciding on a maximum likelihood between said received subsignals and corresponding estimated subsignals.

24. A receiver according to claim 23, further comprising channel estimation means **(44)** for performing a channel estimation used for obtaining said corresponding estimated subsignals.

25. A receiver according to claim 23 or 24, wherein said first diversity transmission scheme is a space diversity transmission scheme.

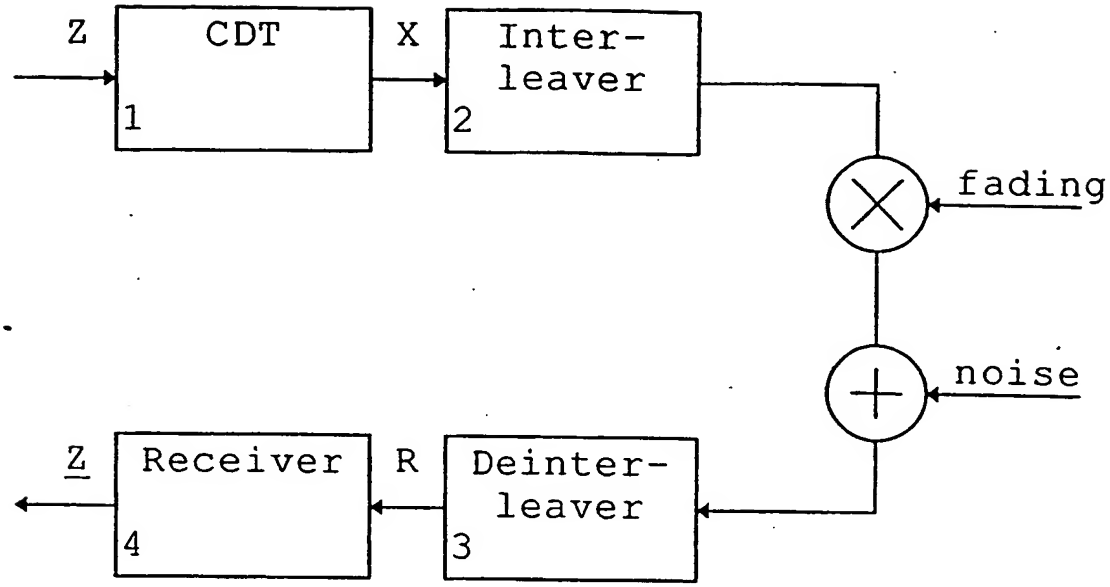
26. A receiver according to claim 25, wherein said space diversity transmission scheme is a selective transmitter antenna diversity scheme.

27. A receiver according to any one of claims 23 to 26, wherein said second diversity scheme is a time or frequency diversity scheme.

28. A receiver according to claim 27, wherein said time or frequency diversity scheme is a complex diversity transformation scheme.

29. A receiver according to any one of claims 23 to 28, wherein said transmission signal is a QPSK signal and said receiving means comprises a bank of 2M correlators, wherein M denotes the number of transmission antennas used in said first diversity transmission scheme.

30. A receiver according to any one of claims 23 to 29, wherein said receiver is arranged in a mobile WCDMA terminal of a cellular network.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CDT
1
X
Inter-
leaver
2
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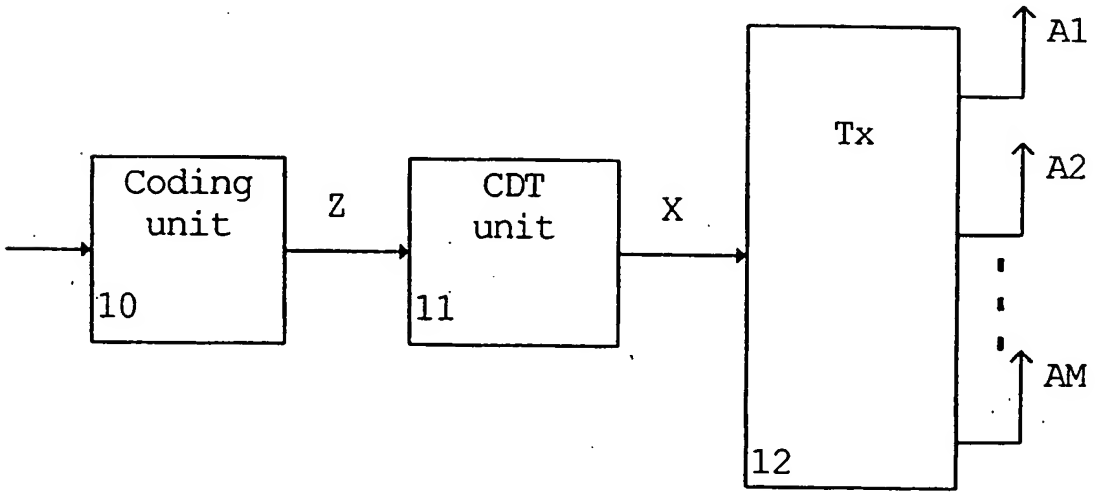
noise
Z
Receiver
4
R
Deinter-
leaver
3

Fig. 1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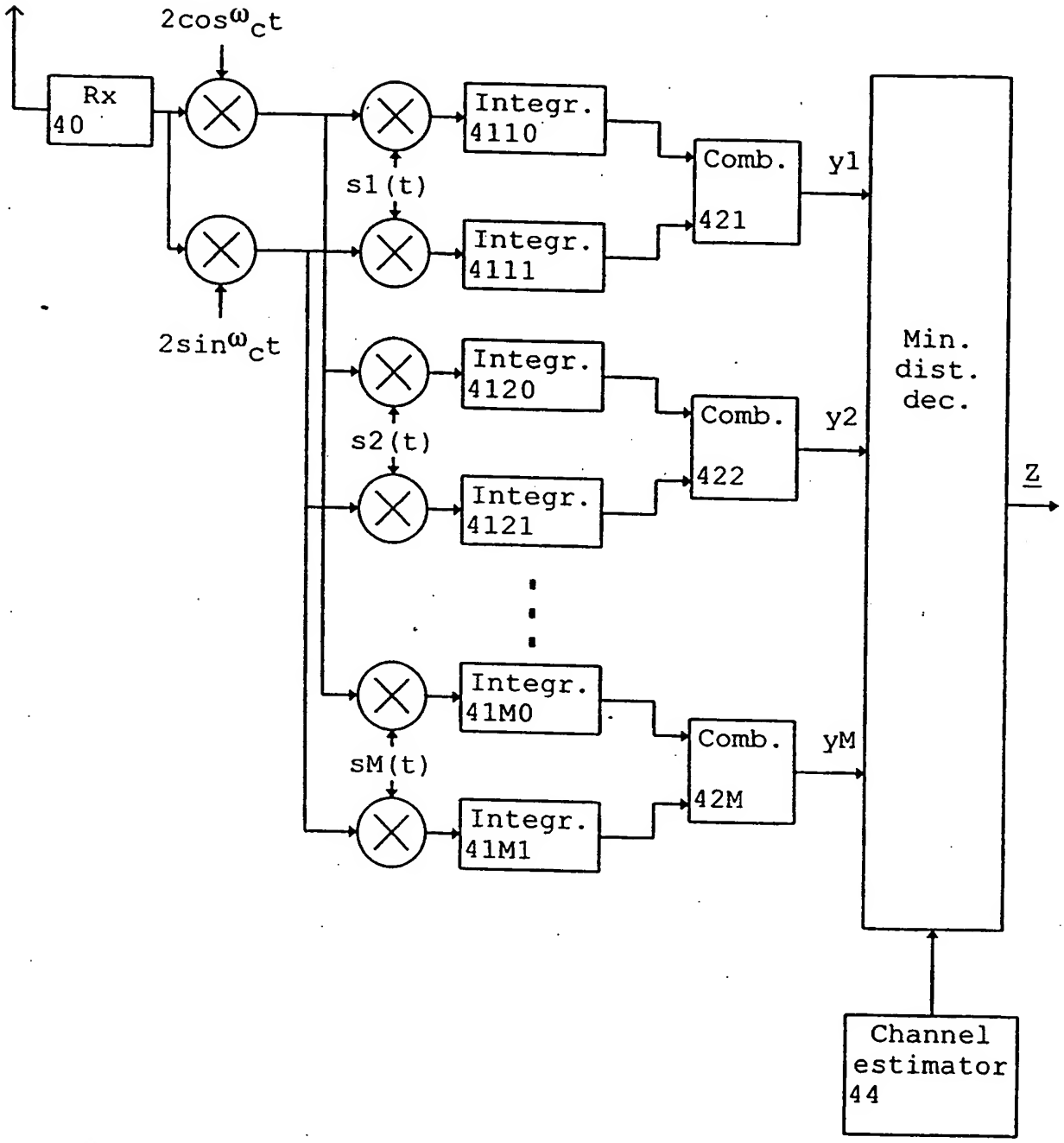
Z
CDT
unit
11
X
Tx
12
A1
A2
AM

Fig. 2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40
Integr.
4110
Comb.
421
y1
s1(t)
Integr.
4111
2sinω_ct
Integr.
4120
Comb.
422
y2
s2(t)
Integr.
4121
Min.
dist.
dec.
Z
Integr.
41M0
Comb.
42M
yM
sM(t)
Integr.
41M1
Channel
estimator
44

Fig. 3

INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/EP 99/04237

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/06 H04L1/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 832 044 A (SOUSA ELVINO S ET AL) 3 November 1998 (1998-11-03) cited in the application column 3, line 18 -column 4, line 33 column 5, line 1 - line 50 column 6, line 25 -column 11, line 19	1-4, 11-20, 22-27, 29,30
A	column 13, line 14 -column 14, line 29	5-9,21, 28

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
10 March 2000	16/03/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	López-Pérez, M-C

INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/EP 99/04237

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DASILVA V M ET AL: "FADING-RESISTANT MODULATION USING SEVERAL TRANSMITTER ANTENNAS" IEEE TRANSACTIONS ON COMMUNICATIONS,US,IEEE INC. NEW YORK, vol. 45, no. 10, 1 October 1997 (1997-10-01), pages 1236-1244, XP000723121 ISSN: 0090-6778 cited in the application page 1236, left-hand column, line 18 -page 1240, left-hand column, line 14	1,4-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. nal Application No
PCT/EP 99/04237

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5832044 A	03-11-1998	NONE	